A

DISSERTATION

ON THE

VARIED DIRECTION

OF THE

FIBRES OF THE MUSCLES,

AND ON THE EFFECTS OF THIS UPON THE MOVEMENTS OF THE BODY;

WITH AN

APPENDIX,

In which the Assertion of a late Author, Mr D. G. YEATES, *(in a Book entitled, Observations on the Claims of the Moderns,* 1798, p. 184, 185.*)*, *that "Dr* J. MAYOW *must be considered as the* Discoverer *of the Important Fact in Physiology, that Oblique Muscles possess the advantages of performing more Extensive Motions than Straight Muscles are capable of doing,"——is Refuted.*

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Of the Varied Direction of the Fibres of our Muscles, and of the Effect of this upon our Motions.

I.

In many of our muscles, the fleshy fibres, instead of running in straight lines, or in lines nearly such, between their origins and insertions, are placed in oblique directions.

Before I attempt to explain the effects of the direction of the fleshy fibres, I shall describe the varieties of this in the different muscles of the human body.

1. In some muscles, as in the recti of the abdomen, the sartorius, the gracilis, &c. the fibres are directed, from the origins of the muscles to their insertions, in nearly parallel lines; and these may be called *straight* muscles; (see Plate 2. fig. 1. of this Treatise.)

2. In others, the muscle is of a triangular shape, and its fibres resemble the spokes of a wheel, or the sticks of a spread fan; and such muscles may be called *radiated*. The fibres in some of them diverge from the origin or fixed point, as is the case in the levator palpebræ superioris; and in others, as in the temporal, subscapularis, or great pectoral, they converge from their origins towards their insertions.

If the edges and middle parts of such muscles are in the same plane, they co-operate, of which the temporal and trapezius may be examples. But in others, as in the deltoid, the fibres are not in the same plane, but inclose a joint, and its oblique sides may be antagonists to its middle in one posture of the arm, viz. its hanging posture, but may co-operate with it when the arm is elevated.

3. In many muscles the fibres are parallel, or nearly so, to each other, but are laid obliquely between tendinous membranes, or between a bone and a tendinous membrane; and as their fleshy fibres resemble in their direction the plumage on one side of the stalk of a feather, they have been called *semipenniform* muscles. The flexors and extensors of the whole hand or foot, and the flexors and extensors of the fingers and toes, furnish striking examples of this kind of structure; (see Plate 2. fig. 2. of this Treatise.)

4. In some places the fleshy fibres run from both sides obliquely downwards, or obliquely upwards to a tendon in the middle of the muscles, resembling in their direction the plumage on both sides of the stem of a feather; and hence such are called *complete penniform* muscles. The flexor longus pollicis pedis (see ALBINUS) is an example, in which the fibres descend; and the rectus extensor cruris (see Plate 2. fig. 3.) an example in which they ascend from the sides of the muscle to the middle tendon. When we compare a complete penniform muscle with a semipenniform

muscle of the same breadth and thickness, as the number of its fibres is double, its strength will also be double to that of the semipenniform muscle.

5. We may next observe a combination of semipenniform muscles in the extensors of the fore-arm or leg, or *compound semipenniform* muscles.

6. In the soleus, we find a combination of complete penniform muscles, or a *compound penniform* muscle; (see Plate 2. fig. 4.)

7. In many other places we find oblique muscles co-operating, although they are not joined to each other by common tendons; as is the case of the two rows of intercostal muscles; and in many of those which are fixed to the head and spine. The sterno-mastoid, splenii, complexi, semi-spinales, multifidus spinæ, are all of them evidently of that description.

2.

Having described the various directions of the fibres in the muscular system, I shall now endeavour to explain the effects these have in the motions we perform.

In many instances the obliquity of the fleshy fibres is so great, that the fibres are very much shorter than if they had run directly from what is called the origin of the muscle to its insertion, or the fibres are much more numerous than if the same space had been covered by straight fibres. Thus, suppose a straight muscle to be fifteen inches long, and that this is cut transversely into

five equal parts, and these laid obliquely in such a manner as that their fibres form the diagonals of triangles, of which the height measures four inches and the basis three inches. If there was no loss of strength by their pulling obliquely, the five short muscles would raise five times the weight; but in fact one-fifth of the force is lost by their obliquity. BORELLUS, De Motu Musculorum, p. 92., proves, That the "potentia oblique trahens est ad resistentiam ut longitudo directionis oblique ad ejus sublimitatem." But after this deduction, the five oblique muscles could raise four times as much as the single straight one of the same breadth and thickness.

3.

We find in reality muscles which correspond very nearly with the above supposed structure. Thus, let us compare with each other two muscles, the figures of which are copied from the very accurate work of ALBINUS, in Plate 2. fig. 1. and 2.

Fig. 1. represents the sartorius muscle in which the fibres, which are of great length, are straight, and nearly parallel to each other. In the second figure, which represents the peroneus longus, which is nearly as long as the sartorius, the fibres are laid obliquely and semipenniform, and do not measure above a fifth part of the whole length of the muscle, from its uppermost to its undermost bundle of fibres; and when we attend to the degree of the obliquity of the muscular fibres, and

suppose these to form diagonals to right-angled triangles, the bases of such triangles, compared with the perpendiculars, will be very nearly in the proportion of 3 to 4; or the muscular fibres form, with their bases and perpendiculars, triangles, the sides of which are in proportion to each other, as the numbers 5, 4, & 3.

From the increase of strength which many muscles gain by having their fibres made shorter, though laid in an oblique direction, it was universally supposed by authors, that the increase of force was the *only* purpose served by the obliquity of their fibres.

4.

But to shew you, in the clearest manner, that nature may have other very different purposes in view, it will be found, that, in various instances, the strength of the muscle is diminished by the obliquity of its fibres. This is the case of many of the short muscles attached to the spine, as in the semi-spinalis colli et dorsi, multifidus spinæ, &c.

But the most striking instance of this is to be found in the intercostal muscles. For it is evident, that if their fibres had been straight or perpendicular to the ribs, they would have been not only much more numerous than in the oblique position, but would have acted upon the ribs with greater force.

In all these instances, one reason of the diminution of force is, that the oblique muscles are longer, and therefore have fewer fibres than straight ones supposed to fill the same space; and the other reason is, that a muscle loses force by pulling obliquely, in the proportion which its length bears to the length of the sine of the angle which it forms with an horizontal line, or to the length of a perpendicular joining two horizontal lines which pass through the origin and insertion of the muscle. Thus, if an oblique muscle deviates one half of a right angle from the perpendicular, it loses the one half exactly of its strength.

Thus, in Plate 3 fig. 1. let AB, BC, represent a log of wood; DD a hook in the roof of a room. Let DB DB represent two straight muscles, exerting their whole force in elevating the log ABBC, but the two oblique muscles DA and DC expend but one-half of their force in elevating the log; for the other half of their force is spent in endeavouring to draw the ends of the log towards each other. That is, the two straight muscles elevate the log with twice as much force as the two oblique muscles do. In other cases the force increases or diminishes according to the obliquity, by the general rule above stated. Thus, the two muscles DE and DF raise the log with one-fourth only of the force of the two muscles DB and DB.

To prove this experimentally, let two pullies A and B, (See Plate 3. fig. 2.) be fixed very near

to each other, in the top of a wall CD, and let two other pullies EF be fixed to the wall at double the distance from each other of the perpendicular height of the first pair of pullies above the second pair; that is, let the length of the horizontal line EF be double to that of the perpendicular line EC or CD. If a rope GHIK be now passed over the four pullies, and two weights L, M hung to its ends, it will be found, that the single weight N, of the same kind and bulk, hooked on the middle of the rope, as at O, will balance both the other weights L and M; because, as the oblique ropes H and I evidently pull inwards in the direction of the horizontal line EF, as much as in the direction of the perpendicular lines EC and FD, they lose one-half of their effects of elevating the weights.

In all examples, therefore, where a space between two parallel lines or bones, such as the ribs, is filled up with muscular fibres, there will be a greater number of fibres when they run transversely than when they are placed obliquely, and they will besides act with more force: And, even when we suppose the number of fibres in two muscles so situated to be equal, the muscle with straight fibres will be stronger than the oblique one, in the proportion exactly which the length of the oblique fibre bears to the straight or perpendicular one.

Hence, in all such cases, some advantages very different from an increase of strength, must be gained by the obliquity.

5.

To discover these, let us now compare, more exactly, with each other, the effects of straight and oblique muscles; and, in the *first* place, let us suppose them to be situated between two parallel lines, (See Plate 3. fig. 3.) Let AHH and KDE represent two parallel lines. Let ABCD represent a pair of straight muscles, and AFGE and AK a pair of oblique ones.

Let us next imagine, that each of these pairs of muscles can in action shorten itself one-third part of its length. On this supposition, the straight muscles will be able to bring the point A, which is supposed to be moveable, down to B, and will then have lost one-third of their length.

But when the pair of oblique muscles had by their action brought the point A down to B, they have not lost one-third of their length, as it is evident that the line BE, which subtends an obtuse angle, is longer than FE, which is equal in length to two-thirds of the oblique muscle.

Hence it appears, that a pair of oblique muscles placed between the same parallels with a pair of straight muscles, can, with less proportional decurtation, produce the same extent of motion that the straight muscles can do.

We may next prove that the oblique muscle has not lost so much of its length as is equal to one-third of the length of the straight muscle. For if we form an isosceles triangle ABL, (see Pl. 3. fig. 4.), as the two sides AB and BK of the triangle ABK

taken together are longer than the third side of that triangle, or than the straight line ALK, it follows, that BK must be longer than LK, or longer than the oblique muscle after one-third of the length of the straight one is taken off from it; or that the oblique muscle, after bringing its insertion to the same point as the straight muscle had done, has not lost so much of its length as the straight muscle had lost.

6.

I have found that I might go a step farther, and prove that two oblique can produce a more extensive motion than two straight muscles of the same length, and which at first sight seem much better fitted for the purpose.

Thus, in Plate 3. fig. 5. let the lines ABC DEF represent two straight muscles; and the lines ALMN two oblique muscles of the same length with the straight ones.

Let us next suppose that these muscles are capable of shortening themselves one-fifth of their length, and that the straight muscles have brought the point A down to B.

Let us next suppose that the two oblique muscles have done the same thing. It is now evident that the oblique muscles have not lost one-fifth part of their length; because the angle BLA of an isosceles triangle being smaller than a right angle, the angle BLN must be larger than it; or the angle BLN being equal to the two

angles ABL and BAL of the isosceles triangle, ABL must be larger than a right angle, and of course larger than the angle LBN; and therefore, as the side of a triangle which subtends the largest angle must be longer than either of the two other sides of the triangle, the side BN must be longer than LN; and therefore the oblique muscle has not lost one-fifth of its length, or has performed, with a smaller decurtation of its fibres, the same extent of motion as the straight muscle of the same length with it.

7.

On the same principles, we can prove that the extent of motion increases with the degree of the obliquity of the muscles. Thus, suppose that the oblique muscles AM and AL, (See Pl. 3. fig. 6.), after bringing the point A down to B, continue to act till they have brought the point B down to C, it appears that they are less shortened in this second action than they were in their first action; for on comparing together the two triangles BGL and CHL, the angles at G and H are equal, because the lines BG and CH are parallel to each other; but the angle HLC being larger than the angle GLB, it follows, that the angle GBL is a larger angle than the angle HCL, and therefore, that the side GL which subtends it, bears a larger proportion to the side BL than HL does to CL; that is, the decurtation of the oblique muscle will be less in its second action than in its first; or

CL is longer in proportion to BL, than BL is in proportion to AL.

Or, the same thing is made manifest in a more simple manner, by comparing together the triangles ABL, BCL, and CDL, in fig. 6., in which it is evident, that the line AL subtending the largest angle bears a greater proportion to BL, than BL does to CL.

Hence, as the degree of obliquity of an oblique muscle is gradually increasing during its action, its force is diminishing, whilst its effect of producing extensive motion is increasing.

8.

Having demonstrated geometrically the general proposition, I shall now illustrate it by applying arithmetical calculation.

Thus, (See Plate 3. fig. 7.), if we suppose two straight muscles, such as our recti abdominis, ABCDEF to be five inches long, and to shorten themselves, in contracting, one-fifth part of their length, they will draw the point A, which we shall call the ensiform cartilage, down to the letter B, or they will move it through a space of one inch only; but if we suppose the same muscles to be placed obliquely, and their origins fixed to the ossa ilia instead of the ossa pubis, and that a line drawn transversely between the ossa ilia measures eight inches, it is evident that they would draw the point A, or ensiform cartilage, three times farther, because they will not lose one-fifth of

their length till the ensiform cartilage is brought down to D, the middle of the line that is drawn between their origins.

Let us next suppose two muscles, each thirteen inches long, to be laid so obliquely, that a line drawn perpendicularly from their insertion to the middle of a line joining their origins (See Plate 3. fig. 8.) measures five inches. If these muscles shorten themselves a single inch, the place of their insertion will be moved through a space of five inches, or five times farther than it could be by the action of two straight muscles.

9.

To make the justness of these conclusions quite evident to those who have not been used to geometrical demonstrations, or arithmetical calculations, I shall now shew, by the figure of a wooden machine, an imitation of the effects of oblique muscles, (See Plate 3. fig. 9.)

In the middle of a piece of wood AAAA, I have cut a groove BC, the sides of which may represent two straight muscles. I now apply on each side a piece of metal BD, BD, representing an oblique muscle, stretched from the side of the base to the top of the perpendicular.

The upper ends of these two pieces of metal are joined together by a pin E, which perforates them and slides in the groove BC. The lower ends D, D of these pieces are slit, and passed over iron pins FF, in the sides of the base of the

machine, by which means the shortening of the oblique pieces or muscles can be represented; and as all the parts of the machine are divided into inches, 1, 2, 3, 4, 5, and parts of an inch, the decurtation of the pieces representing the oblique muscles can be accurately measured, and the motions can be shewn to correspond exactly with the demonstrations before given.

10.

Upon the whole, oblique muscles have the following effects.

1. Although the force of an oblique muscle is less than that of a straight one of the same number of fibres, in the proportion which the perpendicular bears to the length of the oblique fibre, yet oblique muscles, with short and numerous fibres, are employed where great strength is necessary, as in bending the fingers or toes; or where the part to be moved, the hand or the foot we shall suppose, resists with the advantage of a long lever against the muscles which serve for the flexion and extension of the elbow or knee; because, as a small degree of decurtation of the muscles is sufficient, short fibres will answer the purpose as well as long ones; and hence, as in such oblique muscles there may be many more fibres than in longer straight muscles occupying the same space, the oblique are preferred.

This resource of nature is so important, that on recollection you will find that there are more ob-

lique than straight muscles in the human body, and in the bodies perhaps of all other animals; or that in the greater number of muscles, the fleshy fibres are shorter than the direct length between the tendons at their extremities, or between the origins and insertions of the muscles. And the number of oblique muscles is still greater in fishes and aquatic animals, as a greater force is necessary to overcome the resistance of water than that of air.

2. When oblique muscles, consisting of the same number of fibres as straight muscles, are placed between two parallel lines, or between bones or other substances, which, when they are moved, remain parallel to each other, or nearly so, although their loss in strength be exactly in the proportion which their length bears to the direct distance between the parallel lines, yet we have found that they are capable of performing a much more extensive motion with the same proportional decurtation of fibres, or a motion of the same extent with less decurtation of fibres. Nay, that they are capable of bringing the parallel lines into contact with each other, which it is evidently impossible could be done by straight muscles.

The most striking instance of this kind is found in the intercostal muscles; for in this part of the body, nature, for the defence of the heart and lungs, forms the ribs as broad, and the spaces between them as narrow, as is consistent with their safety. Hence straight or perpendicular muscles

between the ribs would not have had sufficient length for producing the proper motion of the ribs; and we even find, that a great degree of their obliquity is required to produce sufficient motion.

In this part of the body we may remark another beautiful application of oblique muscles; for we find a second row of oblique intercostal muscles within the first, serving two material purposes, viz. In the *first* place, That this row compensates for the loss of strength the first row has suffered by its obliquity; and, in the *next* place, That the two rows conspiring, raise the ribs as directly upwards as could have been done by straight muscles, and press them as little forwards or backwards against their articulations as these would have done *.

In various other parts of the body, but particularly in the spine, where there are many joints, and the pieces of bone and intermediate cartilages are thin, straight muscles must have been so short, and their power of contraction so small, that they could not have produced a sufficient degree of motion in the joints of the spine; and hence we have found, that oblique muscles are very generally substituted instead of them.

3. As I have demonstrated that oblique muscles can perform the same extent of motion as straight

* This *latter* circumstance was distinctly remarked by Dr Mayow, De Respiratione, p. 247. and proved experimentally by Dr Haller.

ones, not only with a smaller proportional, but with a smaller actual decurtation of their fibres; and of course, that when they are contracted to the same proportional or actual degree, their motions are more extensive; we may observe in many cases, where an increase of strength is chiefly intended by the obliquity of the fibres of the muscles, that they are employed also for increasing the extent of motion. Thus, the upper and lower portions of the trapezius muscle, or the two lateral portions of the deltoid muscle co-operating, can produce more extensive motion of the scapula and of the humerus, than could be done by the middle portions of these muscles. In like manner, the external and internal oblique muscles of the abdomen co-operating, appear to be capable of bending the thorax forwards in as great a degree as can be done by the recti, although their fibres are considerably shorter.

4. As the oblique muscles can, with a smaller degree of decurtation, perform the same extent of motion as a straight one, it follows, that the same motions performed by them, will be executed in a shorter space of time than could have been executed by straight muscles of the same length, provided we take for granted, that the time in which the action of a muscle is completed, bears a proportion to the length of the muscle. To support in some measure this supposition, we may observe, that similar actions of small animals are completed sooner than those of larger; or if we compare the

action of the multifidus spinæ, which we may suppose to consist of as many short muscles as there are true vertebræ, with the action of a single straight muscle, supposed to reach from the os sacrum to the head, it is evident, that each of the several insertions of the multifidus spinæ would, in the same times, be moved through one twenty-fourth part only of the space through which the insertion of the single long muscle must pass; and therefore, unless we suppose the insertion of the long muscle to move twenty-four times more quickly than each of the insertions of the multifidus, it could not in the same time extend the trunk of the body to the same degree.

5. As the oblique muscles, in performing the same motions as straight muscles might perform, are less shortened than the straight would be, there is a saving of motion, and hence probably less fatigue.

6. Two oblique muscles, by balancing each other, may produce motions in a greater variety of directions than can be done by a pair of straight ones.

In the first place, by acting singly and alternately, they perform the offices of straight muscles, and draw alternately the place of their insertion directly towards its origins, which are generally more distant from each other than the origins of two straight muscles.

If, next, they co-operate with equal strength, the place of their insertion is moved in the dia-

gonal between them, as when the oblique muscles of the abdomen draw the ensiform cartilage towards the ossa pubis.

7. In the last place, each of them may act with different degrees of force, and hence move the place of their insertions in all the diagonal lines we may suppose to be drawn between them ; or we may compare the pair of oblique muscles to the outer sticks of a spread fan, and the variety of the directions of the motions they are capable of producing, to the co-operations of intermediate sticks of the fan. In consequence of this motion in diagonal lines, the four recti muscles of the eyeball enable us to follow an object moving before us in a circle.

APPENDIX,

In which the Assertion of a late author, Mr D. G. Yeates, *that "Dr* J. Mayow *must be considered as the Disco- "verer of the important fact in Physiology, that Oblique "Muscles possess the advantages of performing more ex- "tensive motions than Straight Muscles are capable of "doing," is refuted.*

A late author, Mr D. G. Yeates, M. B. *, not contented with observing, that Dr J. Mayow was the first who objected to the opinion which had been popular from the days of Galen, That the external and internal intercostal muscles were antagonists to each other, and who endeavoured to prove that they co-operated, has ventured to allege, that "Dr Mayow must be also considered as "the discoverer of the important fact in physiology, that "oblique muscles possess the advantages of performing "more extensive motions than straight muscles are capable of doing."

He pretends, "that the principle is clearly explained "by Mayow;" though he is pleased to add, that "he is "by no means so prejudiced in favour of his author, as "not to admit, that Dr Monro has very ably extended "the principle of obliquity to the action of the muscles "in general †."

* See his book, entitled, Observations on the Claims of the Moderns, 1798.

† Pages 184. and 185.

But, upon these assertions of Mr Yeates, I would observe, in the *first* place, That Dr Haller, who had read, and quotes Mayow's works, and who had considered the subject more fully than any other person of the present age, and by numerous experiments, chiefly on living animals, which I quoted in the Observations I published on the Muscles, p. 16., ascertained the fact, that the external and internal intercostal muscles co-operate in inspiration, (which I have since found, but did not then know, had been taught by Dr Mayow, otherwise I should have quoted him along with Dr Haller,) did not perceive in Mayow, or in his own writings teach, any new principle throwing light on the general effects of oblique muscles, or tending to prove that oblique muscles possess the advantages of performing more extensive motions than straight muscles are capable of doing.

I shall next, as Mr Yeates proposes, allow Dr Mayow to speak for himself in the following paragraphs, on which the claim for him rests.

In the Editio novissima of his "Opera omnia Medico-Physica, 1681, tractatibus quinque comprehensa," Tractatus Secundus, De Respiratione, p. 245., he states his arguments for his opinion, that the intercostal muscles, even the interior ones, serve for enlarging the chest: "Musculi intercostales etiam interiores pectori ampliando inserviunt;" and in the next page, 246., he attempts to explain the reasons why the intercostal muscles have an oblique position, "Cur musculi intercostales obliquam positionem habent," in the following words:

"Et hoc ulterius adhuc ostendit musculorum intercostalium obliquus, et contrarius situs. Ideo enim videtur natura musculos illos oblique costis inseruisse, *(quanquam iisdem sursum, aut deorsum movendis recta insertio melius*

conveniret), quia costarum interstitia adeò minuta sunt, ut si musculi isti rectis angulis insererentur, breviores essent, quàm ipsa musculorum natura patitur ; quapropter ut dicti musculi justam longitudinem obtinerent, eos oblique, uti fit, costis insertos esse, oportet : cum tamen obliqua hæc positio ad costas sursum movendas minus idonea sit ; ideò natura machinatrix sapientissima, diversi sitûs musculos constituit ; ut, dum hinc inde æquali nixu oblique costas trahunt, costæ interea rectà sursum ascendant, prout in *Tab.* 2. *fig.* 4. ostenditur : ubi musculis exterioribus *a a* et interioribus *c c* simul se contrahentibus, costa inferior, mobiliorque, non oblique, sed rectà sursum ascendat ; perinde ac si à musculo, rectis angulis ei affixo, traheretur *."

Without any comment, I shall now appeal to the reader whether Dr Mayow has said any thing more than a person might have done who was entirely ignorant of geometrical principles, or of the advantages which co-operating muscles gain by their obliquity.

He rests the whole advantage of obliquity of the intercostal muscles on their being *longer* than *straight* ones

* "The oblique and contrary situation of the intercostal muscles shows this still farther. For although a straight insertion would suit better for moving the ribs upwards or downwards, yet Nature seems to have inserted them obliquely into the ribs, because the interstices of the ribs are so minute, that if these museels were inserted at right angles, they would be shorter than the nature of muscles suffers ; wherefore, that the said muscles might obtain a just length, it was necessary to insert them, as is done, obliquely into the ribs. But as this oblique position is less fit for moving the ribs upwards, therefore Nature, a most wise contriver, hath disposed these muscles in different situations, that whilst with an equal effort they draw the ribs obliquely here and there, the ribs in the mean time ascend straight upwards, as is shewn in Tab. 2. fig. 4., where the external muscles *a a*, and the internal *c c* contracting themselves at the same time, the inferior and more moveable rib will ascend, not obliquely, but straight, as if it were dragged by a muscle fixed to it at right angles."

between the same parallels, without attempting to prove, or suggesting, that oblique muscles, placed between the same parallels with straight ones, could, with a smaller decurtation, perform as extensive motion as straight ones; or that, with the same decurtation, they could perform more extensive motions; or that from their obliquity they derived any other advantage than that of being *longer*. And he was so far from having the most distant conception that oblique muscles could perform more extensive motions than straight ones of the same length, that, in the passage above quoted, he affirms the direct contrary. "*Ideo enim videtur musculos illos oblique costis inseruisse, quanquam iisdem sursum aut deorsum movendis recta insertio melius conveniret.*"

What new principle, then, is Dr Mayow supposed to have discovered with regard to the effects of oblique muscles?

But not to rest here, I shall proceed to shew, by quotations from his own works, the inconsistency of Dr Mayow with himself, and to prove undeniably, that he not only did *not discover*, but did not even *suspect* that oblique muscles could perform more extensive motions than straight muscles placed between the same parallels. The reader will find the proof of what I here allege, in the subsequent Chapter II. of Mayow, which I have reprinted below at full length, from the Opera Omnia Medico-Physica of J. Mayow in 1681.

"CAP. II.

"*Musculorum brevis Descriptio. Item quænam Pars Musculi primario contrahitur.*

De Fibris Carneis Musculi.

"In musculorum anatomicâ dissectione primò se conspiciendum offert integumentum membranaceum, mus-

culo cuivis quaquaversus obtensum; sub quo in conspectum veniunt Fibrarum carnearum series; quæ tendinibus oppositis, et parallelis, ipsæ etiam parallelæ cum angulis obliquis inseruntur. Prout à *Cl. D. Stenone* primò animadversum est.

" Porrò observare est Fibrillarum Membranacearum, pene infinitarum admirandas series quæ inter se parallelæ, fibras carneas transversim, sed obliquis angulis secant: nempe eodem modo, quo Fibræ carneæ tendinibus, etiam Fibrillæ fibris carneis, situ tamen opposito, inseruntur: Et sicut Fibræ arcte conjunctæ Tendines, ita Fibrillarum collectio ex parte saltem aliquâ ipsas fibras componere videtur. Uti in *Fig.* 2. *Tab.* 3. apparet, quæ Fibrarum, et Fibrillarum series exhibet, quatenùs in musculis diù satis coctis conspiciuntur.

Fibrillarum descriptio.

" Hactenus Fibras carneas musculi præcipue, et primario contractionem inire, ab Authoribus in re anatomicâ versatissimis statutum est: ex nostra autem opinione (quod eorum pace dictum velim) non Fibræ, sed Fibrillæ, transversum iisdem insertæ, præcipuas in contractione musculari partes obtinent, id quod ex indiciis saltem probabilibus colligimus. Etenim si contractio in fibris carneis fieret, tunc ad debitam musculi contractionem necesse erit, ut Fibræ multo magis quàm ipse Musculus in longitudine abbrevientur; cùm enim fibræ non secundum musculi longitudinem disponantur, sed oblique tendinibus inserantur, prout in prædictâ figura videre est, hinc fit, quòd musculi contractio fibrarum contractione multò minor sit; et ad justam musculi contractionem requiratur, ut fibræ multo magis quàm ipse musculus contrahantur: tantam autem fibrarum contractionem revera in motu dari non existimo: præterquam enim quod in vivisectionibus fibrarum hujusmodi contractionem conspicere non licet: si fibræ carneæ in tantùm contraherentur,

Eædem primario contractionem ineunt ex authoris sententiâ.

Fibrarum situs obliquus musculi contractioni minus convenit.

musculum minimmensum excrescere oporteret, quod tamen non contingit.

At fibrillarum positio recta eidem perficiendo idonea est.

" Cæterùm ut musculi contractio à Fibrillis perficiatur, tanta earum contractione, et intumescentia minime opus erit; utpote quarum series, ut in figura dicta manifestum est, secundum musculi longitudinem disponuntur, ita ut musculi contractio fibrillarum contractioni æqualis fuerit. Jam verò cum naturæ mos sit via maxime compendiaria uti; probabile est musculi contractionem potiùs per Fibrillarum, quàm Fibrarum contractionem fieri. Huc etiam facit quòd, cum fibrillæ minutissimæ brevissimæque sint, earum contractio etiam ad dimidias, vix quidem notabilis erit: Etenim dum Fibrillæ universim contractionem patiuntur, res haud secus habet, ac si fibræ secundum musculi longitudinem extensæ, in varias corrugationes cogerentur, cujusmodi quidem earum contractio, utcunque satis magna, sine notabili tamen musculi intumescentia fieri post.

Fibrillæ musculi constrictioni conveniunt.

" Quibus insuper addo, quòd fibrillæ abbreviatæ fibras carneas ad invicem adducant, et constringant; ita ut probabile sit musculorum contractionem ab iis perfici; siquidem musculus contractus insigniter constringitur, et durescit; id quod nulla alia ratione, quàm fibrillarum contractione fieri posse videtur. Verùm de musculi contracti constrictione infrà fusius dicetur.

" Ad hæc, naturæ consuetudo talis est, ut operationes suas minimorum ope plerunque perficiat; ita ut fibræ nimis crassæ, rudesque esse videantur, quàm ut contractio muscularis in iis primario fiat; easque potius sanguini trajiciendo, quàm motui animali perficiendo inservire probabile est, uti infra ostenditur.

Uti etiam ejusdem robori.

" Denique et huc spectat, quòd fibrillarum brevitas, numerusque pene infinitus, ad musculorum robur, eorumque tractionem validius perficiendam conducit. Plane ut

fabrillæ sive earum numerum, seu magnitudinem, seu denique situm perpendimus, contractioni musculari instituendæ multo, quàm fibræ carneæ aptiores videantur. Id quod insuper ex ipsa autopsiâ magis adhuc confirmatur; quantum enim in Vivisectionibus inspiciendo assequi unquàm potui, fibræ carneæ in musculi contractione, tanquam à fibrillis transversis attractæ, propius ad invicem accedere; et non ipsæ abbreviari, sed fibrillarum contractionem sequi videntur.

"Quòd verò ob ligaturam utrique fibrarum carnearum extremitati injectam, muscularis contractio cessat, fibraque ipsa non uti aliàs in tumorem assurgit, uti à *Cl. D. D. Willisio* annotatum est, hoc propterea fieri existimo quòd sanguinis, Spirituumque Animalium motus, per ligaturas injectas interrumpitur, quorum tamen influxus ad fibrillarum contractionem necessarius est."

Cur fibrâ in utroque termino ligatâ musculus contractionem inire nequit.

In the above chapter, the reader will observe that he describes a muscle as composed of *fleshy fibres*, and of an almost infinite series of *membranaceous fibrillæ*, (which last have been called by all modern anatomists, threads of the cellular substance.)

He tells us, that hitherto it has been maintained by authors, that the contraction of a muscle is primarily performed by its fleshy fibres, but that, in his opinion, not the *fleshy fibres*, but the *fibrils* inserted *transversely* into the fleshy fibres, perform the chief part in muscular contraction, and that the *straight position* of these fibres is fit for performing it. To which he adds, that the *fibrils*, when shortened, draw the *fleshy fibres* towards each other, so that it is probable that the contraction of muscles is performed by them, seeing that a contracted muscle is remarkably constricted and hardened, which can be no other way done than by the contraction of the *fibrils*;

that the *fleshy fibres* seem to be too thick and rude for performing primarily muscular contraction, and that they rather serve for transmitting the blood, than for accomplishing animal motion.

In fine, that the shortness of the *fibrils*, and their almost infinite number, conduce to the strength of muscles; so that plainly, whether we weigh the number of the *fibrils*, or their magnitude, or their *situation*, they seem much fitter for muscular contraction than the *fleshy fibres*. This is moreover confirmed by ocular inspection; for that, so far as he could ever observe in dissecting living animals, the *fleshy fibres*, as if dragged by the *transverse fibrils*, approached each other, and were not themselves shortened, but seemed to follow the contraction of the *fibrils*.

He prints on the margin of p. 302. the heads of the contents of this page in the following words: "Fibrarum situs obliquus musculi contractioni *minus* convenit, at *fibrillarum positio recta* eidem perficiendo idonea est." He delineates in his figure 2d of Table 3., which is exactly copied in Plate 3. fig. 10. of this dissertation, a semipenniform muscle, in which the fleshy fibres *ccccc* are represented as passing obliquely from the tendon A on one side of the semipenniform muscle, to the tendon B on the other side of it; and his *fibrillæ membranaceæ, d d d d*, are painted and described as passing transversely from one of the *fleshy fibres* to another, by which his *fibrils* are delineated as being parallel with the tendons on the sides of the muscle, or as running in straight and parallel lines from the one end of the muscle to the other. "Et sicut fibræ arcte conjunctæ tendines, ita fibrillarum collectio, ex parte saltem aliqua ipsas fibras componere videtur, uti in fig. 2. Tab. 3. apparet."—See the copy of MAYOW's figure in Plate 3. fig. 10.

If, therefore, instead of delineating a semipenniform muscle, he had delineated in the same manner a portion of the two rows of intercostal muscles, the *fleshy fibres* would have appeared to run from one rib to another in the oblique direction; but his *fibrillæ membranaceæ* would, consistently with his general description of a muscle, have been represented as running straight or perpendicularly from one rib to another; so that if we adopt Dr MAYOW's doctrine in Cap. II., we should conclude that the motion of the ribs is primarily, chiefly or solely, performed by membranaceous fibrils or threads of cellular substance, passing straight, perpendicularly, or at right angles from one rib to another; or he retracts, and directly contradicts what he had before taught of the effect of the obliquity of the fibres of the intercostal muscles.

It is therefore proved undeniably, and very evidently, by mere quotations from his own book, that Dr MAYOW was inconsistent with himself, and had no title whatsoever to be considered "as the discoverer of the important "fact in physiology," as Mr YEATES calls it, "that "oblique muscles possess the advantages of performing "more extensive motions than straight muscles are capable of doing."

It of course follows, that Mr YEATES, and certain other persons, who have ascribed this discovery to Dr MAYOW, had either not read his book with proper attention, or had misunderstood it, or had misrepresented it.

Fig. 1.
Sartorius.

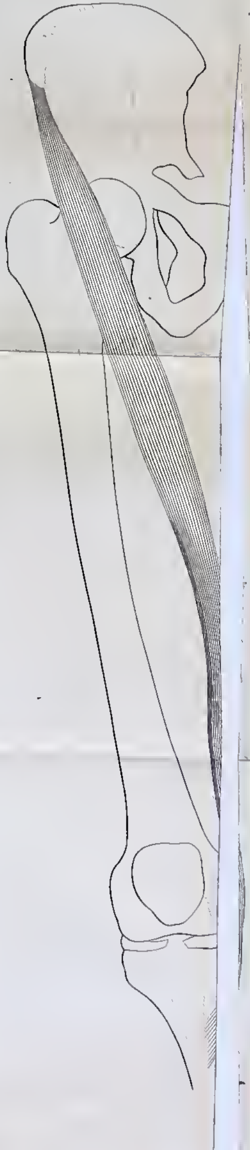

Fig. 2.
Peroneus longus.

Fig. 3.
Rectus cruris.

Fig. 4.
Soleus.

W. Archibald sculp.t

Fig. 1.

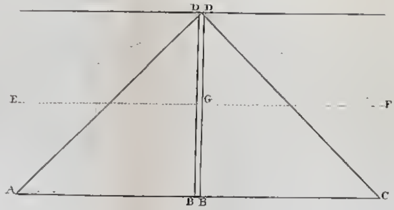

Fig. 2

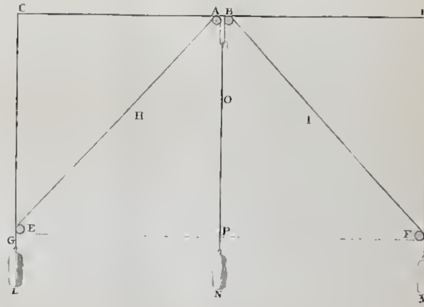

Fig. 3

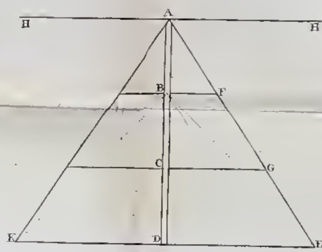

Fig. 4

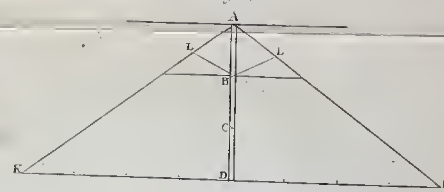

Fig. 5.

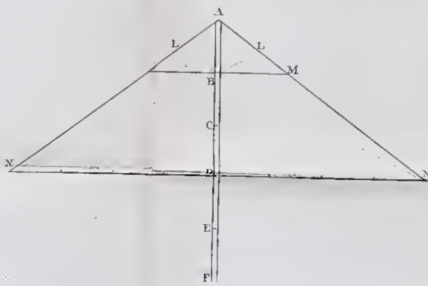

Fig. 6.

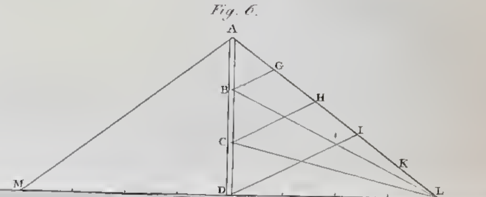

Fig. 7.

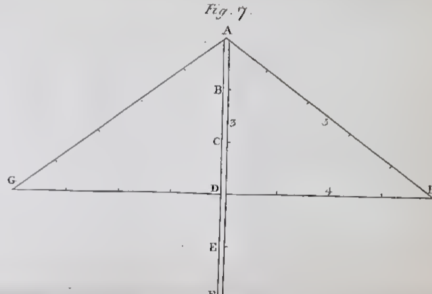

Fig. 8

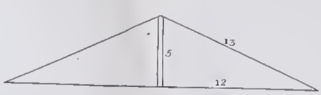

Fig. 9

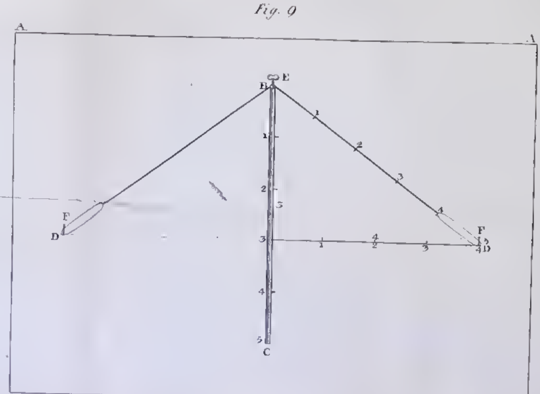

Fig. 10.

Copied from Meyer Tab. 3 Fig. 2